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14. ABSTRACT

The IPS (Interplanetary Scintillation) system at KSWC (Korean Space Weather Center) in Jeju Island, South Korea can measure the selected radio sources around the sky at 327 MHz which is same frequency for use in Japan during last 30 years to derive solar wind velocities and densities. UCSD have developed IPS 3-D analysis model which determine the heliographic 3-D structure based on the data from Solar Terrestrial Environment Laboratory (STELab), Japan. The new KSWC system is dedicated to IPS observation and observed data can be used for UCSD model input in addition to existing STELab system. Verification and calibration are being done. This study summarizes: the single site spectral fitting technique for KSWC IPS array which gives solar wind velocities and verify the technique with values derived from 3-site values at STELab; implemented independent version of the UCSD 3-D IPS model at KSWC for space weather forecasting purpose based on the observed data primarily from Japan and Korea (www.spaceweather.go.kr/models/ips); test of combining the measured IPS data between Japan and Korea; standardization of the observed IPS data format from existing IPS radio systems like STELab, KSWC, MEXART; comparison of single-site IPS observations with those from three-site IPS system.

15. SUBJECT TERMS
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"**IPS Space Weather Research: Korea-Japan-UCSD**"

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Abstract:

Recently commissioned IPS (Interplanetary Scintillation) system at KSWC (Korean Space Weather Center) in Jeju Island, South Korea can measure the selected radio sources around the sky at 327 MHz which is same frequency for use in Japan during last 30 years to derive solar wind velocities and densities.

UCSD have developed IPS 3-D analysis model which determine the heliographic 3-D structure based on the data from Solar Terrestrial Environment Laboratory (STELab), Japan. The new KSWC system is dedicated to IPS observation and observed data can be used for UCSD model input in addition to existing STELab system. But to do that, it is required to combine the observed data between different observing facilities which need verification and calibration against well developed system like STELab.

In this study we have studied and tried following collaborative effort

1) Derive the single site spectral fitting technique for KSWC IPS array which gives solar wind velocities and verify the technique with values derived from 3-site values at STELab
2) Implement independent version of the UCSD 3-D IPS model at KSWC for space weather forecasting purpose based on the observed data primarily from Japan and Korea. The outputs from the model have been visualized on the web (www.spaceweather.go.kr/models/ips).
3) Test of combining the measured IPS data between Japan and Korea.
4) Standardization of the observed IPS data format from existing IPS radio systems like STELab, KSWC, MEXART etc
5) Comparison of single-site IPS observations with those from the Nagoya, Japan STELab three-site IPS system.
6) Activities among UCSD, Japan and Korea for joint IPS analysis.

Contents

I. Introduction:

The IPS observation is a remote-sensing technique which measures the scintillation of the radio source to derive the physical parameters like solar wind velocities and densities. This is the one of the unique way to observer the solar wind from the earth. The IPS system at STELab, Japan has been operating since 30 years for this purpose. On the other hand, UCSD have developed IPS tomographic model which determine the 3-D heliospheric structures. This model successfully describes the propagation of solar wind from the Sun to Earth and beyond. The IPS model has input data from the STELab system to iteratively fit the measured IPS parameters from the earth. So far the STELab system is the only working system which observes the IPS sources routinely from April to December for the IPS model input.

There are other ground based IPS systems which measures the radio sources to derive solar wind velocities and density variations like Ooty in India, MEXART in Mexico. IPS system at SWPC, South Korea recently implemented and starts to observe the radio sources. This system use same frequency as STELab, 327Mhz, and dedicated to IPS observation. Furthermore, As Japan and Korea belongs to same time zone, it will be very useful if the data from the two systems can be combined and used for the IPS model input. This is the main motivation of this study among UCSD, Japan and Korea.

To properly convert single IPS measurement to physical value, we need careful investigation of the spectral fitting process based on the raw time series data. This spectral fitting method is originally developed by Ooty group and STELab three-site system also applied this method to check their accuracy compare with three-site cross correlation results. The KSWC system use 327 MHz, same with STELab, for scintillation measurements and SETLab solar wind group, Prof. Kojima, gave valuable advice about the design and implementation of IPS system in Korea from the design stage. The spectral fitting method, applied to KSWC, which convert scintillation measurements to solar wind velocities are described and comparison with three-site is provided.

Determine the 3-D structure of Sun-Earth space gave great opportunity to monitor the propagation of the solar wind material and transients like CME to Earth, which cause Geomagnetic storms. IPS tomographic model developed by UCSD is one of many other models and based on the ground based IPS observations unlike others. KSWC implements the local running version of the IPS model for their nation's space weather forecasting purpose. With this running version of model, we have modified the input of the model so that it can accept IPS data from KSWC IPS array or STELab systems. Tests are carried out with KSWC data only case, combining KSWC data and STELab data case etc.

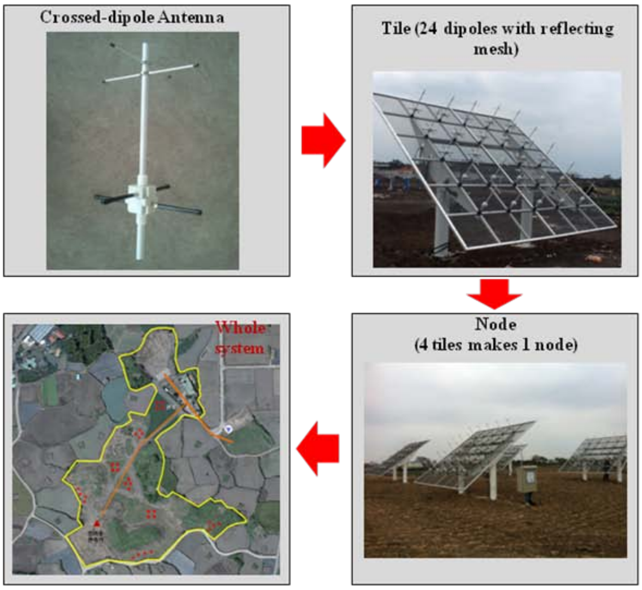
To run the heliospheric 3-D IPS model with combined data from several different IPS systems. The standard format of the data is required. To test the data assimilation between KSWC and STELab IPS system and in future to combine any data from other IPS systems, collaborative work was done among UCSD, STELab and KSWC. The standard format of IPS data independent to hardware system is suggested. This makes the IPS model can accept easily IPS data from different systems for space weather monitoring purpose.

The collaborative work was mainly based on international meeting among UCSD, STELab and KSWC. The activities for the collaborations during the period allocated by AOARD are described.

II. Analysis

1. Newly commissioned KSWC IPS system

We briefly explain here the newly implemented IPS system in KSWC, South Korea. In the design stage of the system, we studied the IPS system in STELab and get the great help from Prof. Kojima and Prof. Tokumaru. As a result we implemented IPS array which consisted of 32 tiles and each tile have 24 dipole antennas working at 327 Mhz. Unlike the STELab system, the KSWC can tract the radio sources via the beam forming technique.



Antenna	• Crossed Dipole with LNA • Center Freq: 327MHz
Tile	• 24 dipole on 1 tile • Beam former
Node	• 4 tiles = 1 node • Node box • A/D conversion and GPS clock sync.
Whole system	• Total 768 antennas on 32 tiles with control and data processing system

Bellows are expected system specification

- **32 tiles deployed over 250 x 250 m^2 (1tile=24 dipole antennas)**
- **Frequency range : 327 MHz**
- **Instantaneous bandwidth : 10 MHz**
- **Continuum and spectrum modes**
- **Dual polarization**
- **Field of view : ~$(1\ rad)^2$ or $(10\ deg.)^2$ depending on observation mode**
- **Beam size (angular resolution) : ~15'**
- **Effective collecting area : ~ 700 m^2**
- **Receiver temperature : ~100 K**
- **Point source sensitivity : 10 mJy @ 100 seconds integration**
- **Time resolution : 1ms or less**
- **Observing modes**
  - **Phased array mode for solar wind monitoring**
  - **Interferometer mode for radio sky imaging**
  - **Both modes for variable objects**

This array is dedicated to IPS observation so far, but has ability to observe other radio sources at different mode.

2. Spectral fitting method applied to KSWC IPS system

The observed interplanetary scintillation is just the time-dependant fluctuations of receive radio signals on the ground. To extract the information from these signals, we need some data processing and fitting procedure. Here we explain the method applied to KSWC IPS system to obtain the solar wind velocity information.

To test the accuracy of the method we developed, the observed data sets from STElab are used. These IPS data are presented in Table 1.

Table 1Toyokawa IPS data

Source	YRMNDY	Dist(AU)	Velocity(km/s)	Scintillation index
3C255	2011/10/11	0.44	469	0.227E+02
3C273	2011/10/11	0.21	304	0.103E+02
3C283	2011/10/11	0.27	465	0.586E+02
3C286	2011/10/11	0.61	411	0.536E+02
3C298	2011/10/11	0.39	278	0.268E+02
3C298	20110/11/04	0.37	314	

Velocities in tables are determined from three-site observations so that we can compare the values from spectral fitting method we developed.

Observed time series does not give the solar wind velocity and density variation, but we can obtain the related index from the signal. Scintillation index m, and g-values are two parameter we can obtain from the observation. Scintillation Index m and g-values are given bellows.

$$\mathrm{m} = \left(\frac{\text{rms intensity fluctuation}}{\text{mean source intensity}}\right) = \int (\mathrm{P}(\upsilon) - \mathrm{P_{WN}})/\mathrm{P_{WN}} d\upsilon$$

$\mathrm{P_{WN}}$: white noise in power spectrum, υ : frequency

$$\mathrm{g} = \frac{\mathrm{m}}{< m >}$$

Index m depend on the distance from the Sun to line-of-sight of observation. According to Figure 1, at 327 Mhz, scintillation index have maximum value (Pmax) around 40 solar radius. So we can divide the region according to this maximum value. In weak-scintillation region, we have linear relation between electron density and power spectrum, so as the distance from the Sun decrease, the index m increase.

Distnace P	Region	Characteristics	
$\mathrm{P} > \mathrm{P_{max}}$	Weak-scintillation	Linear relation between radius signal strength and electron density variation	Good for IPS observation at 327Mhz
$\mathrm{P} < \mathrm{P_{max}}$	Strong-scintillation	No clear relation between radio signal and electron density variation.	

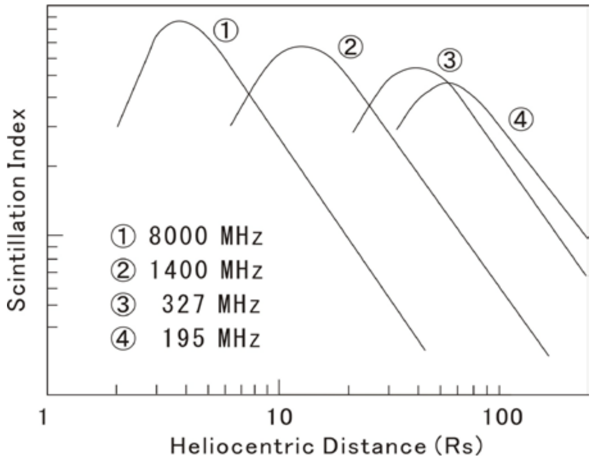


Figure 1 Variation of scintillation index at various frequencies

To get the solar wind velocity and density variation information from the time-series radio signal, we use power spectrum by fourier transform.

$$\text{power spectrum} = \text{fourier}[\text{autocorrelation}] = |\text{fourier}[x]|^2$$

The procedure we adapted is follows. From the time-dependant intensity signal observed. We applied filtering the noise from the time-dependant signal. Usually signals higher than 3 sigma of average value are extracted out.

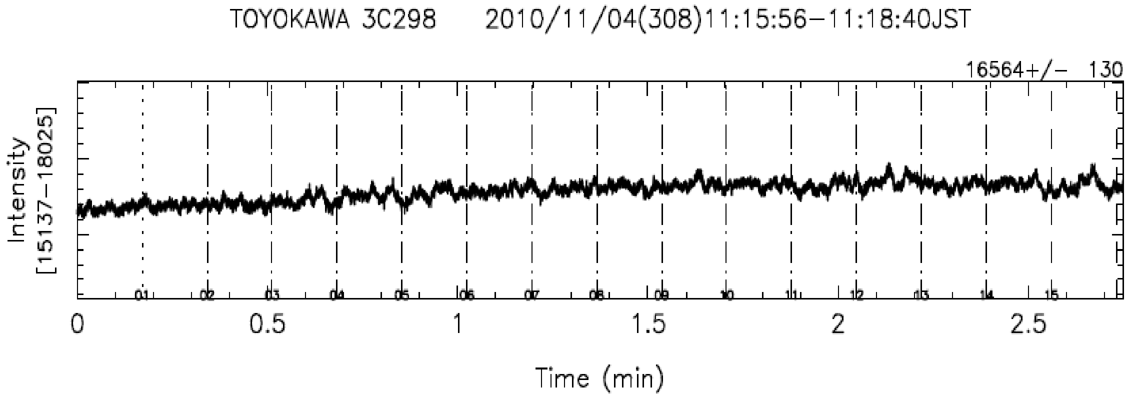


Figure 2 3C298 time series data

After filtering out the noise value, we applied cons-bell window to the time series. For the FFT, each time series are divided by 512 data points. As the time series have about 8250 points, the FFT results of every 512 points are added to get the final power spectrum.

$$\text{total power spectrum} = [\text{power spectrum}[0{:}512] + \text{power spectrum}[1{:}512] + \cdots + \text{power spectrum}[{:}8250]]$$

The 512 points for each FFT are optimum values, if we have more data points it have more high frequency resolution but take longer time. If we have less data points than 512, we do not have enough frequency resolution. For the FFT, we use the software library FFTPACK included in Numpy of Python language.

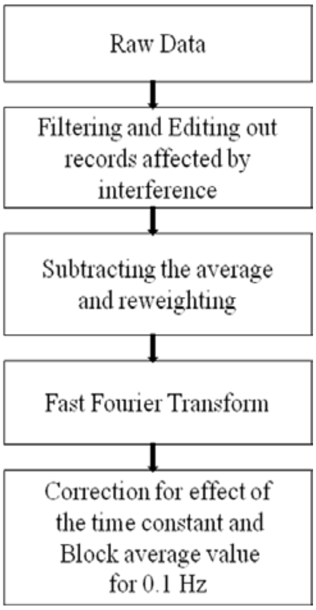


Figure 3 Data Processing Algorithm

The final power spectrum we get is presented in Figure 4. This is the result obtained by STELab. Two horizontal lines in the figure mean with or without white noise components. With this power spectrum, now we are ready to fit the power spectrum with theoretically know models.

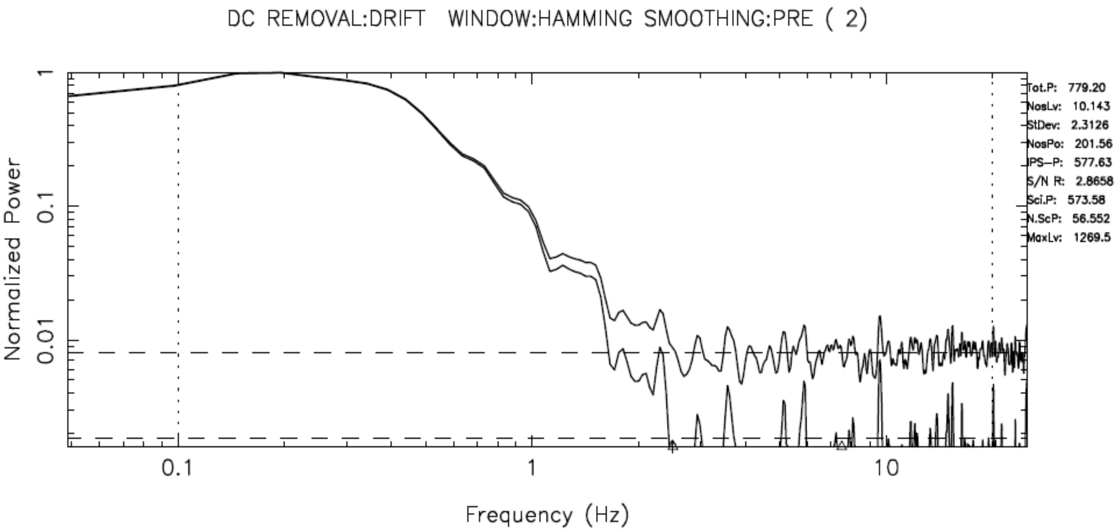


Figure 4 3c298 Power Spectrum

We use following power spectrum model to fit the observed data.

$$p(f,z)dz = 2\pi(\lambda r_e)^2 \int \Phi_{ne}\left(q_x, q_y, q_z = 0, z\right) F_{diff}(q_x, q_y, z) \times F_{source}\left(q_x, q_y, z\right) dq_y\, dz$$

This is the theoretical model described in Manoharan and Ananthakristan (1994). This model works when the radio sources are observed at weak-scintillation region. The model has four component, first component is constant for normalization. The second part is related to turbulence. it has the form of $\Phi_{ne} \propto R^{-4} q^{-\alpha}$. The relation $\Phi_{ne} \propto R^{-4}$ gives weight for local level of turbulence. This is from the study of Armstrong and coles (1978). The relation $\Phi_{ne} \propto q^{-\alpha}$ comes from the measurements of plasma from cosmic ray (Intriligator & Wolfe 1970, Unti,Neugebauer & Goldstein 1973) and observation of phase scintillation (Woo& Armstrong ,1979). α (power-law index) also effects to the final solar wind velocity, The value of 11/3 is suggested by Woo&Armstrong 1979. But the exact values are not determined yet. Generally $\alpha = 3.5 \pm 0.5$ is the most used approximation. We also use this value for the model fitting. The third part $F_{diff}(q_x, q_y, z)$ explains Fresnel propagation filter. This filter related to flux intensity fluctuation and electron density variation and acts as high-pass filter. The last part, $F_{source}(q_x, q_y, z)$ 7 explains the optical characteristics of radio sources. As opposite to Fresnel filter, this part acts as low-pass filter and have forms of symmetrical-gaussian brightness distribution. The final model equation havs following components explained.

$$P(f) = c \int \frac{dz}{V_x(z)} \int dq_y \sin^2\left(\frac{q^2 z_0 \lambda}{4\pi}\right) e^{-\left(\frac{qz_0\theta}{2.35}\right)^2} R^{-4} q^{-\alpha}$$

$$q_x = \frac{2\pi f}{V_x(z)}$$

$$V_x(z) = \frac{V_p}{(z^2 + p^2)^{1/2}}$$

$q = (q_x^2 + q_y^2 + q_z^2)^{1/2}$ is 3-D wave vector, λ is observing frequency, r_e is classical electron radius, x is direction of solar wind flow, z is direction to observed radio source.

Wave vector q assumes isotropic in theory, but many observed values show non isotropic properties of q. This mean we have to consider the axial-ratio according to observed frequency and radio source. (Kojima 1979).

The model equation explained above is compared with observed power spectrum to get the solar wind velocity value. As KSWC have single IPS system, this model fitting method is only way to get the solar wind information. On the contrary STELab have three IPS systems, the cross-correlation method can be applied which is know more accurate.

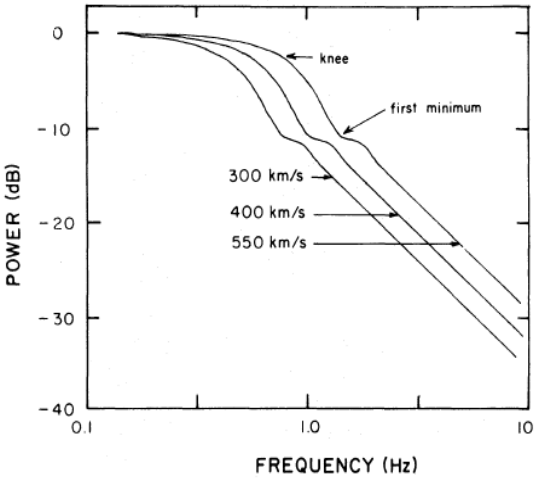


Figure 1. Model spectra with $\alpha = 3.6$ and $\Theta_S = 0$ mas showing the effect of solar-wind velocity. The Fresnel knee and the first minimum of Fresnel oscillation are indicated on the figure.

Fugure 5 Model power spectrum

As we can see from Figure 6, the model power spectrum has bump at low frequency region, it is called Fresnel Knee. The frequency shows Fresnel Knee related to wave number so the changes in solar wind velocity effects the shape of model power spectrum. The model power spectrum also has dependency on IPS source size. As the size of IPS source increase, the high frequency power in model power spectrum decrease.

For the actual fitting we have four unknowns, which are elongation of source (ε), the power-law index (α), solar wind velocity (V_P) , source size (θ_s). Elongation of the source can be obtained from the observation. We simulate the effect of specific model parameter when we fix other parameters to investigate the effect of one specific model. We found that solar wind velocity values are main parameter which affects the model power spectrum. Figure 6-8 bellows shows the effect of solar wind velocity on model power spectrum (green) compared to observed power spectrum (blue).

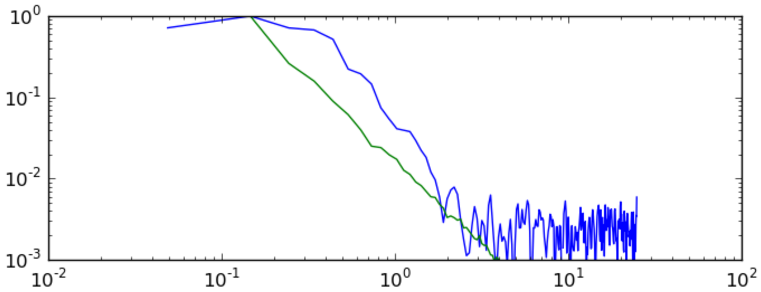


Figure 6 3c298 fitting V=200

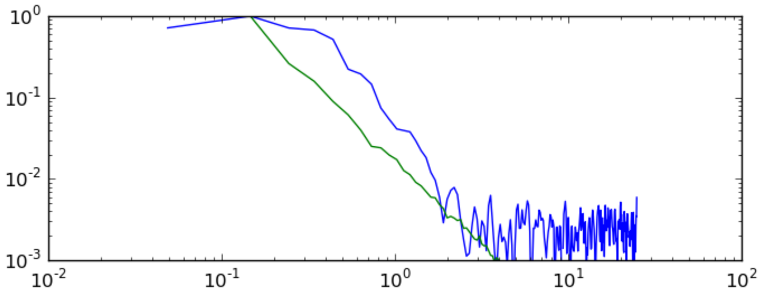


Figure 7 3c298 V=250

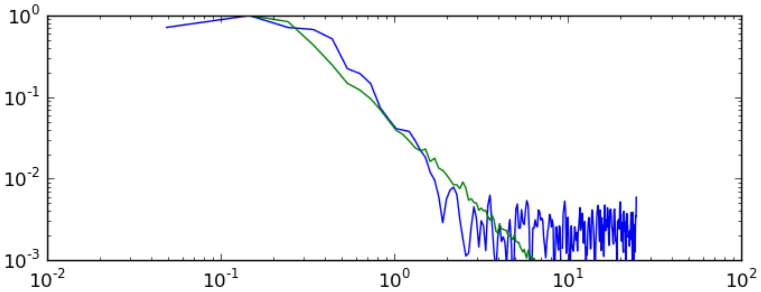


Figure 8 3c298 V=300

By iteratively fitting the theoretical and observed power spectrum, we can decide best matching parameter set. This is the procedure we get the solar wind velocity from the observed IPS scintillation.

For automatic fitting of the observed power spectrum with model, we have also developed process to fit the two power spectrum. This is the block diagram of the data processing.

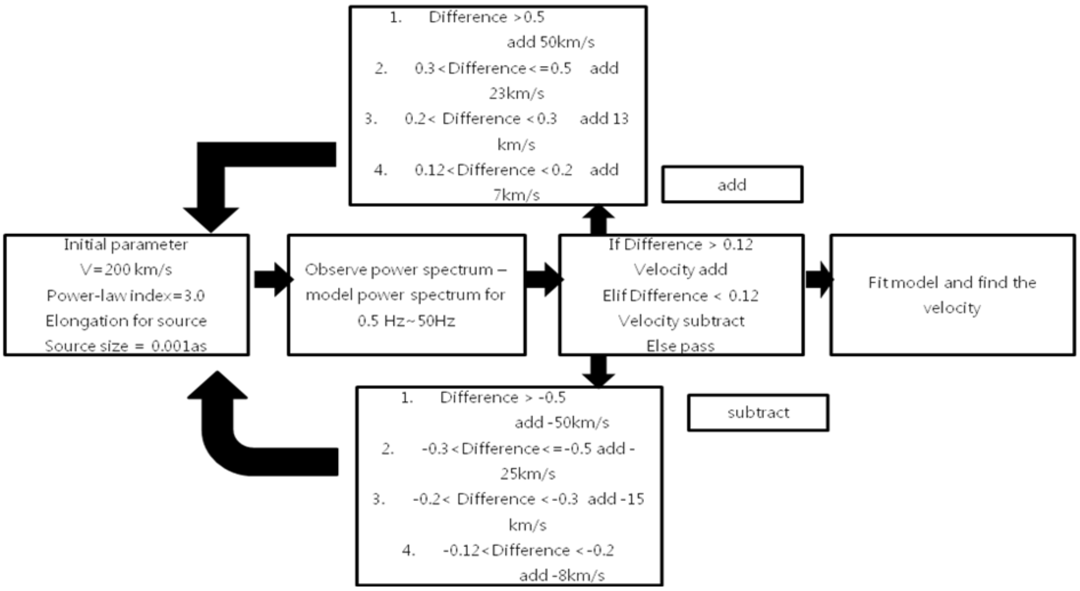


Figure 9 Automatic model fitting algorithm

The table shows model fitting results explained so far. Solar wind velocities determined by model fitting method we developed have good match with values determined by three-site cross-correlation methods. There are small differences in final velocities but we decide that the single site model fitting method to extract solar wind velocity is reliable and can be applied at KSWC data.

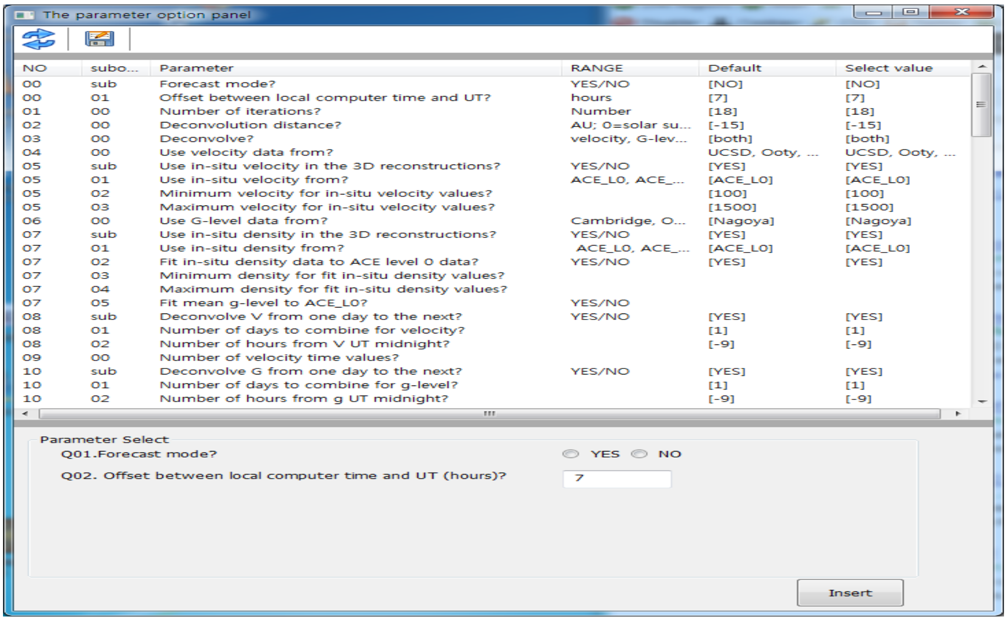
Source	YRMNDY	Dist(AU)	Velocity(km/s) In STELab	Velocity(km/s) Model fitting
3C255	2011/10/11	0.44	469	440
3C273	2011/10/11	0.21	304	330
3C283	2011/10/11	0.27	465	380
3C286	2011/10/11	0.61	411	###
3C298	2011/10/11	0.39	278	270
3C298	20110/11/04	0.37	314	345

3. Implementation of UCSD tomographic IPS model to KSWC

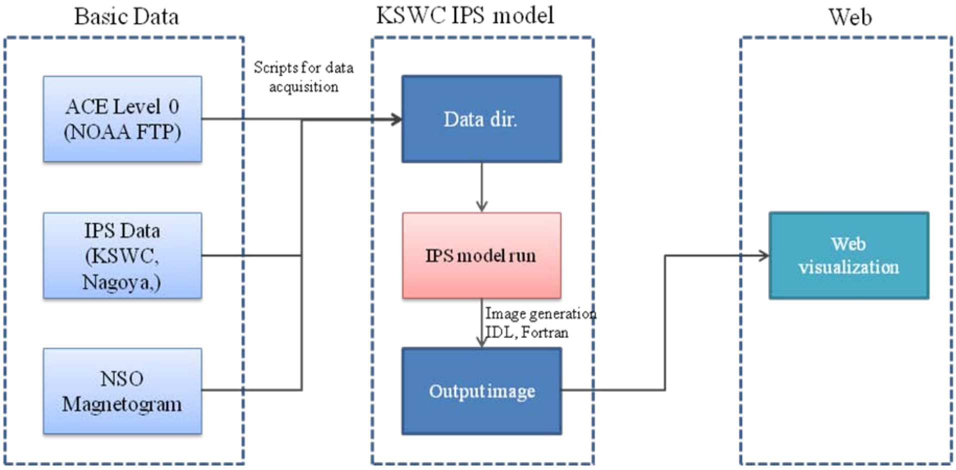
Based on agreement of collaboration among UCSD, STElab and KSWC, a version of IPS 3-D tomographic model has been implemented on local server at KSWC for routine run. The same model currently operates at UCSD and NASA-Goddard Community Coordinated Modeling Center (CCMC). Also the web-based visualization software is developed. The UCSD 3-D tomographic model successfully measure *in-situ* solar wind parameters from both archival and real-time data sets, this can be used to predict the propagation of high speed solar wind and CME which can affect the Earth. As KSWC IPS system expected to supplement data from STELab to provide better research into IPS studies. Data from the KSWC IPS system can be used firstly perhaps to supplement data from Japan during times when the STELab arrays are not operating, to cross-calibrate the analysis from the two systems, and finally to attempt collaborative comparisons of the IPS signal pattern on the rare occasions when a radio source lines up along the radial propagation direction of outward-flowing solar wind.

For the purposes of scientific research, real-time analysis of solar wind conditions at Earth provides a daily confirmation of how well these programming techniques work, and insight into the physical principles governing solar wind flow and magnetospheric interactions. As these real-time analyses and research products become available, we intend for their use at KSWC, Japan, the NASA-Goddard CCMC, and at UCSD and to be made available on the UCSD web site.

To run the UCSD version of IPS tomography model, software program which handle the input parameters, ACE level-0 data, observed IPS data, solar magnetogram image from NSO are developed. Also the scripts for automatic running of the model and setting various parameters for specific model runs are developed on local server of KSWC. The GUI bellows shows parameter editing tool to edit the more than hundred input variable required to run the IPS model.



The basic block diagram of how to run the implemented IPS program is given bellows. With basic input data IPD model runs automatically to produce output which is visualized on KSWC web.



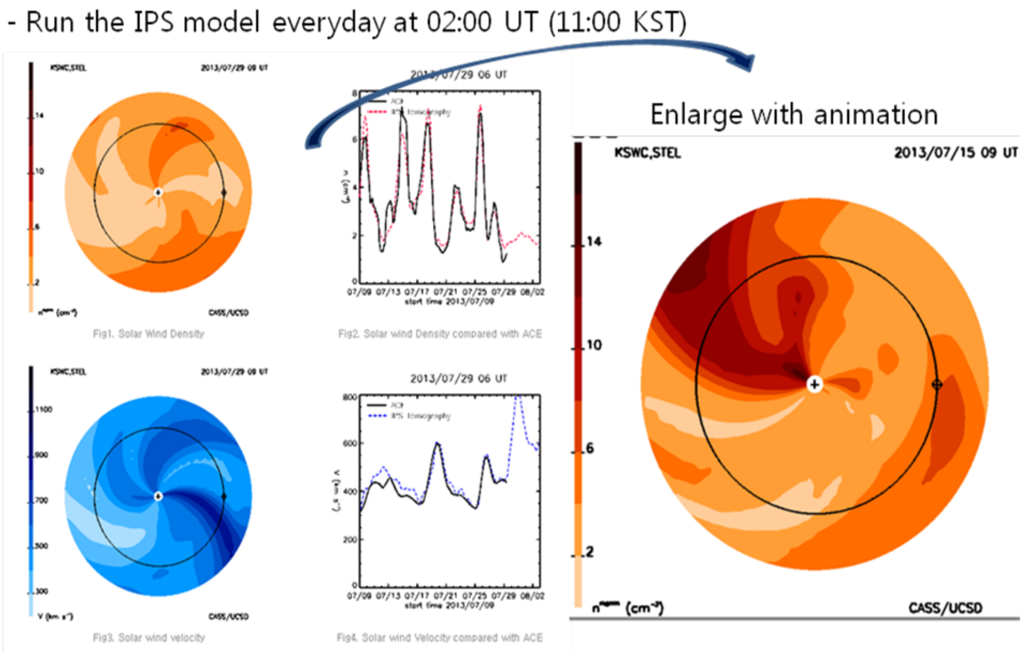
Specification of computer servers for IPS model run is given bellows. Two servers runs same program and one is acting as primary, the other works for backup in case of emergency.

	IPS-server-1	IPS-server-2
Vender/Model #	IBM / X3250 M4	
CPU	INTEL Xeon E3-1220 3.1GHz	
MEMORY	4GB(1x4GB) PC3-10600 CL9 ECC DDR3 1333MHz LP UDIMM	
Power	1 x 300W Power Supply	
HDD	2 x 500GB 7200 SATA 3.5"SS	
ODD	UltraSlim Enhanced SATA combo	
Storage	none	
OS	CentOS 6.4 64bit	

The installed software libraries are follows. In addition to main model which is ipdtd_20n_inp_mag, required software libraries are setup and scripts developed for automatic input parameter acquisition and output data visualization are installed.

	Installed program	Function
Server system configuration	g95 Fortran Compiler	Fortran compiler (IPS Tomography source compile)
	Semi Library	IPS Tomography library
	Python	Program control
	IDL	Image processing and display
Model	Ipstd_20n_inp_mag	Main program
Required scripts	Automatic data acquisition	ACE, STEL, NSO data acquisition
	Scripts for IPS tomography model runn ing	Control the model run
	IPS Tomography image script	IPS Tomography image acquisition
	Model parameter script	Modify the parameter of tomography

The final model output can be found at KSWC web site. The model runs once in a day at 02:00 UT.. (www.spaceweather.go.kr/models/ips). The ouput on the web consists of 4 sections, upper part shows ecliptic cut of solar wind density distribution and plot compared with ACE data. Lower part shows solar wind velocity distribution and plot compared with ACE in-situ measurements.



4. Test of combine observed IPS data between STELab and KSWC

With the UCSD version of IPS model, we have tried to test any difference in model output according to IPS data input. We test in three cases, first with only KSWC data, second with only STELab IPS data, third combine the KSWC data and STELab data. Bellows are results of the tests.

Table 2 Data 2013/06/27

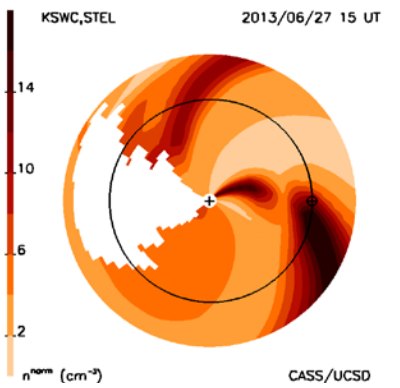
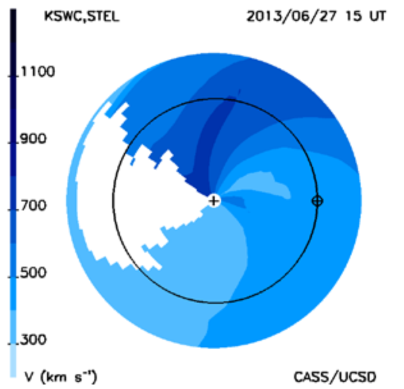
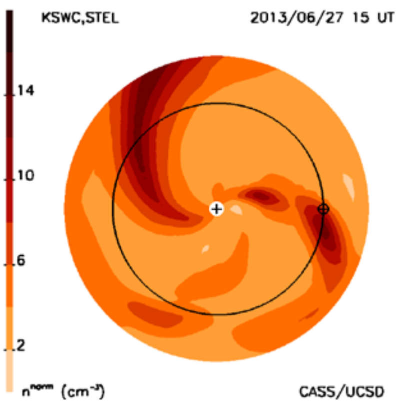
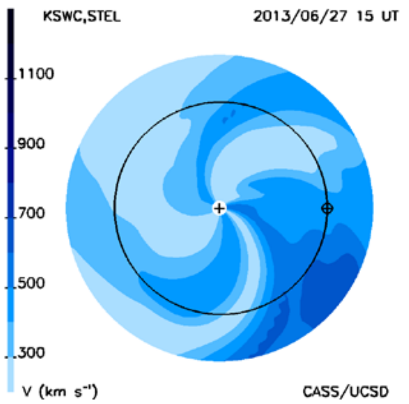
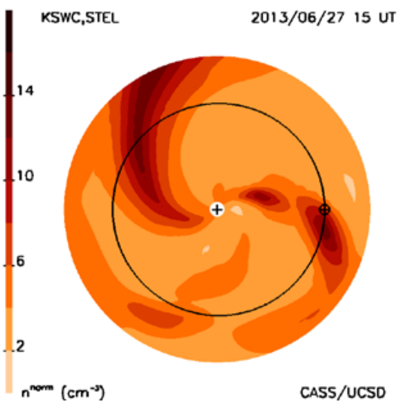
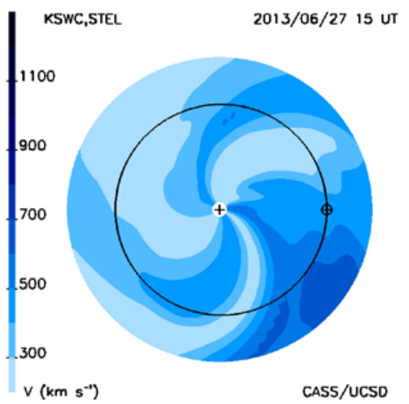
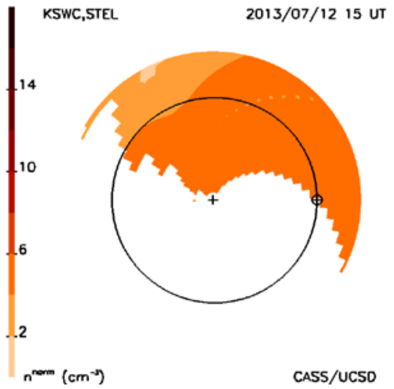
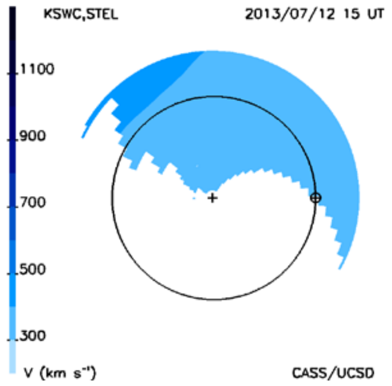
Input Data	Density distribution output	Velocity distribution output
①KSWC input data		
②Nagoya input data		
③KSWC and Nagoya input data combined		

Table 3 Data 2013/07/12

<table>
<tr><th>Input Data</th><th>Density distribution output</th><th>Velocity distribution output</th></tr>
<tr><td>①KSWC input data</td><td>
</td><td>
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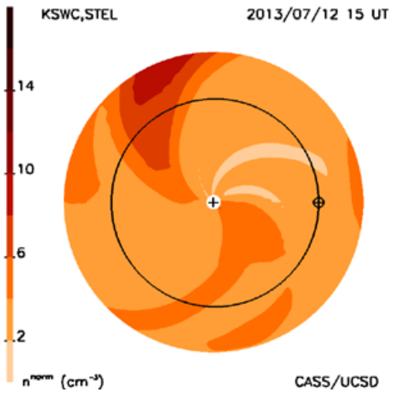
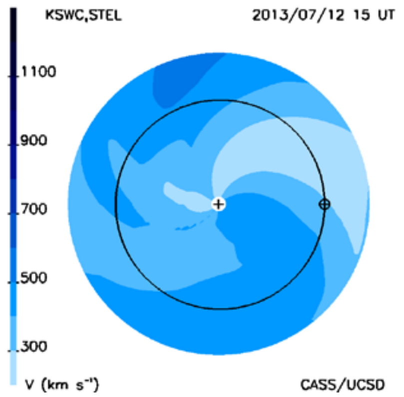
<tr><td>②Nagoya input data</td><td>
</td><td>
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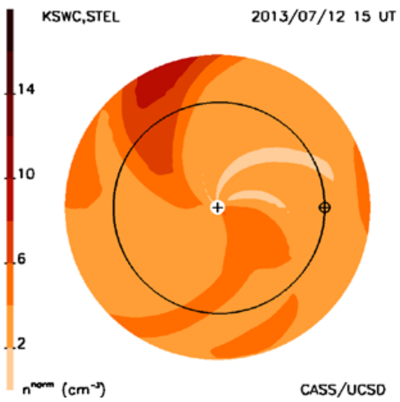
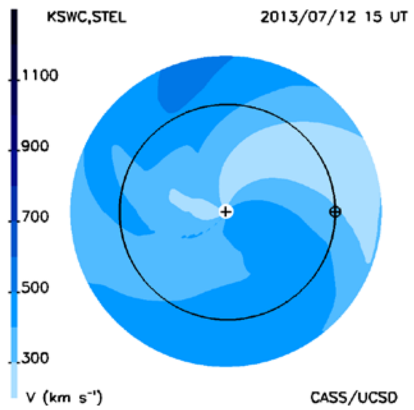
<tr><td>③KSWC and Nagoya input data combined</td><td>
</td><td>
</td></tr>
</table>

From the test, we have learned that if there are not enough input data the output results have some blanks with does not show the proper distribution of velocity and density. When we combine the KSWC data and STELab data, there are not much difference in shape but have different intensity

This test make us to know that the UCSD IPS model are only accept the STElab IPS data format for the model run and to accept input from other IPS systems the input part of the program should be change or we have to match the IPS data format exactly with that of STELab. This results in a matter of data standardization among different IPS systems discussed in next chapter.

5. Standardization of IPS data

Several data analysis methods allow heliospheric densities, velocities, and energy to be observed remotely. These techniques incorporate measurements of interplanetary scintillation (IPS). New in Asia at the Korean Space Weather Center (KSWC) is an IPS system that has been commissioned this year, and is now at operation with data on the Web at: . This system views a limited number of radio sources at 327 MHz, the same radio frequencies that have been studied for over 30 years from the Solar TErrestrial Environment Laboratory (STELab) Japan. At the University of California, San Diego (UCSD) with the help of our Japanese colleagues, we have pioneered these techniques to remotely view heliospheric structures and map their shape in three-dimensions using these unique data sets. For IPS data from STELab, these analyses have been used as data are available in real time since the year 1999. Preliminary versions of the programs to provide these analyses in archival format and in real time, are available at STELab and at UCSD, at the NASA-Goddard Community Coordinated Modeling Center (CCMC), and now at KSWC using STELab data.

Our plan was to begin a collaborative effort that joins all three systems and software. This will include incorporating available KSWC measurements into the three-dimensional (3-D) analysis from STELab in order to provide better coverage whenever there are outages, and for scientific collaborative purposes. For the purposes of scientific research, real-time analysis of solar wind conditions at Earth provides a daily confirmation of how well these programming techniques work, and insight into the physical principles governing solar wind flow and magnetospheric interactions.

The discussion of IPA data standardization starts at a two-day get-together following the CAWSES II Symposium held in Nagoya, Japan 18-22 November 2013. More than 20 participants discuss the current IPS data format and propose the future unified format. After the series of discussions among participants via e-mail, the candidates of unified format are determined.

Bellows are proposed standard format of IPS data.

Date Date yyyymmdd
Start-UT Time hh:mm:ss
Site Observing site
Source name of the IPS radio source
RA-J2000
DC-J2000
Limb
Dist.
Lat.
PA
Elong

Vel.
V-err
g-value
g-err
Method Singl. St. in case we have single station analysis values

Vel.
V-err
g-value
g-err
Method CC in case three station cross correlation is applied (STELab only)

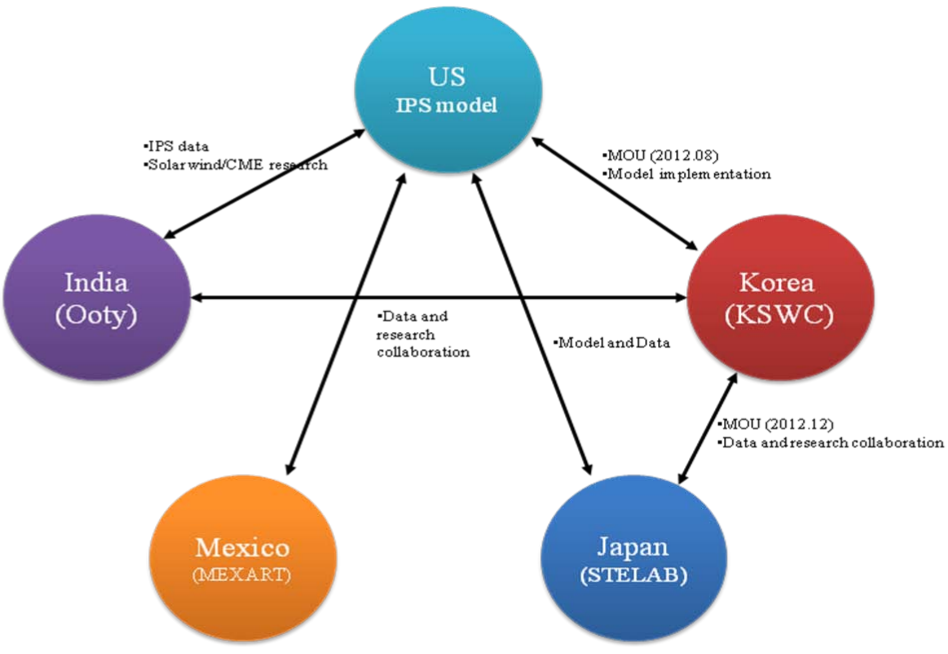
As these real-time analyses and research products become available, we intend for their use at UCSD (**http://ips.ucsd.edu**), KSWC (**http://www.spaceweather.go.kr/models/ips**), at Japan (**http://stesun5.stelab.nagoya-u.ac.jp/index-e.html**), at the NASA-Goddard CCMC; see, for instance:_**http://iswa.ccmc.gsfc.nasa.gov:8080/IswaSystemWebApp/index.jsp?i_1=387&l_1=35&t_1=304&w_1=933&h_1=493&s_1=0_0_10_3**, and at MEXART (MEXican ARray Telescope), Mexico (**http://www.mexart.unam.mx/**).

6. International collaborative activities

The diagram bellows shows the international activities we have made during the research period. The current active countries operating their own IPS system, India, Japan, Mexico and Korea, have abilities to provide the IPS data for the 3-D IPS model which used for space weather forecasting in real time. When we have standard IPS data provider around the world and 3-D IPS model, it is possible to run the model more frequently compare to current once in a day run with only STELab data. In this respect, collaborative works among IPS systems are essential.

The topics we have discussed are

1) Single site IPS model fitting technique and error analysis
2) Make standard IPS data format for general use
3) Combine IPS model with 3D-MHD model (ENLIL) i.e. Providing IPS boundaries so that the 3D-MHD modeling (ENLIL) operated by the KSWC can be driven by the IPS real-time analysis from STELab



The IPS collaborative Workshop (November 23&24, 2013):

A collaborative international meeting funded in part by the three institutions – UCSD, STELab, and the KSWC, the announcement to colleagues specifically working on these IPS projects is attached. Held as a two-day get-together following the CAWSES II Symposium held in Nagoya, Japan 18-22

November 2013, we have ~20 participants (funded in part by the CAWSES symposium) that they attended the two-day meeting following CAWSES II.

The three items on the two-day IPS workshop agenda include:

a) Comparison of single-site IPS observations with those from the Nagoya, Japan STELab three-site radio system.

b) Standardization of the data format from existing IPS radio systems.

c) The potential for using heliospheric Faraday rotation for measuring Bz remotely.

To make headway on these items in the allotted time we restrict each member speaking to remain strictly on subject and to come to a consensus about how to continue future work on each.

As a background UCSD post-doctoral scholar (Mejia-Ambriz, 2012; 2013), Bernard Jackson (Jackson et al., 2013), and Munetoshi Tokumaru (Tokumaru, 2013) reported on the single site spectral analysis of IPS data that allows velocities to be determined from a system such is available at the KSWC. This analysis technique (used for over a decade with IPS data from Ooty, India) has recently been shown to be prone to large errors when weak radio sources are utilized in these analyses (Tokumaru, 2013). The current technique is currently being used to measure velocities from the radio sources from the Ooty, India radio telescope, the KSWC array and the STELab Toyokawa array. UCSD now has a way to quantify the errors in these single site measurements, and we wish to disseminate this information to others in the field. All primary participants using these IPS techniques intend to be present at the IPS workshop where this information will be presented.

To make headway on the analysis of IPS g-level data as a proxy for heliospheric density, we wish to further study the results of Jackson et al. (2013), where comparisons were made with the remotely-sensed scintillation-level measurements from IPS and comparison with shocked plasma. Jackson et al. (2013) can find no abnormal enhancement of the IPS response when shocked plasma is present in the heliosphere, and this is an interesting study because of the IPS use in determining the extent of bulk plasma density values and the IPS ability to forecast heliospheric shocks as they pass near the Earth.

Finally, most of the persons who can measure current heliospheric Faraday rotation at the two new large recently commissioned radio arrays (the Murchison Widefield Array – MWA, and the LOw Frequency ARray - LOFAR) is present at the IPS workshop. A report on preliminary attempts to provide these observations is presented to the community about their efforts.

The week following the IPS workshop (November 25-29, 2013):

A subset of the group from the IPS workshop remains in Japan at Nagoya University to continue work on the projects discussed at the IPS workshop. These funds include subsistence and partial salary for those working on these topics at the IPS workshop. The persons involved include the primary participants named on the current AOARD proposal: 2 staff from the KSWC group, 4 from UCSD, and those able to participate from STELab. The topics discussed are:

a) Providing a robust single-site IPS velocity measurement system with errors for the KSWC, STELab.

b) Providing a standard IPS g-level measurement system that can be interchanged between different radio arrays.

c) Providing an automatic UCSD tomographic routine that mixes different IPS data sets from different locations to enable their use from different time zones as radio sources pass above different longitude locations.

III. Conclusion

We expect that these analyses will provide viable results as they become used by personnel at the KSWC, STELab, and at UCSD. As these data sets become available they will also be disseminated for use at the CCMC. An in-situ inclusion version of the IPS 3-D reconstruction program currently operates in preliminary form at both the KSWC, STELab and at the CCMC Projected potential magnetic field measurements using the UCSD kinematic model are currently available and the program on the Web and at the CCMC has been updated to provide the latest Wilcox Solar Observatory and Kitt Peak National Observatory magnetic field extrapolations.

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